UNITED STATES PATENT AND TRADEMARK OFFICE

INVENTOR(S):	Gailus, et. al	GROUP ART UNIT:	2614
APPLN. NO.:	09/933,364	EXAMINER:	Hashem, Lisa
FILED:	August 20, 2001	Confirmation No.:	7135
TITLE:	A FEEDBACK LOOP WITH ADJUSTABLE BANDWIDTH		

DECLARATION UNDER 37 C.F.R. § 1.131

This declaration is being filed electronically

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

1. We, Paul H. Gailus, Manuel Gabato, Kevin McCallum, and Jeff Wilhite are inventors of the present application and hereby make this declaration.

2. The subject matter of Claims 1, 2, 4-9, 11, 13-18, 20 and 22 of the instant patent application stand subject to a rejection under 35 U.S.C. 102(e) as being anticipated by United States Patent No. 6,859,097 filed on May 14, 2001 entitled "Radio Frequency Feedback Amplifier circuits" to Chandler (Chandler patent).

3. This declaration is submitted to establish the conception of the subject matter of the rejected claims prior to the effective date (May 14, 2001) of the Chandler patent coupled with due diligence from prior to said effective date to a subsequent filing of the instant application.

4. The subject matter of the rejected claims was conceived in the United States or other provincial region permitted by the Rule (37 C.F.R. 131) before the effective date (i.e., May 14, 2001) of the Chandler patent.

5. The subject matter of the rejected claims was the subject of a written disclosure (ID No. 4766 H) prepared after conception, and that on July 10, 2000 the invention disclosure was submitted to a patent committee of Motorola Inc., the assignee of the instant patent application, for the purpose of documenting and evaluating invention disclosures for patent protection. The attached written invention disclosure, ID No. 4766 H, is a true copy of the original written invention disclosure on which the instant patent application is based.

6. After submission of the written disclosure, Motorola, Inc. decided to pursue patent protection on the written disclosure and that thereafter, in due course; a patent application was prepared and filed in the United States Patent Office on August 20, 2001.

7. Prior to May 14, 2001 to August 20, 2001, we exercised due diligence to prepare, review and file the patent specification and claims for the present application.

8. All of the above statements made of our own knowledge are true and all statement made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that willful false statements may jeopardize the validity of this application or any patent issuing thereon.

SIGNATURES:

Paul H. Gailus	10/9/2007 Date
Manuel Gabato	10/9/2007 Date
Kevin McCallum	10/9/07 Date
Jeff Willhite	10/9/07 Date

MOTOROLA CONFIDENTIAL PROPRIETARY (Upon completion)

MOTOROLA

MOTOROLA PATENT COMMITTEE

For TAM Department Use ONLY	
Disclosure Number 4766 H	Date 07/10/2000
Division(s): Systems Research	
Patent Committee Action:	

Disclosure for Patent Committee Review
Submitted Pursuant to Employee Agreement
DISCLOSURE TYPE:

SHORT FORM ☐ *When using the short form (single page), the review committee may request additional information before reaching a decision.*

EXPANDED ☒ *Use additional pages in the expanded form if you feel more information will be necessary for the committee to reach a decision.*

1. Title of Invention: Multi-band, Closed-Loop, Linearized Transmitter Using Cartesian Feedback

1a. Key Words: Variable, Amplifier, Sum, Zero, Compensation

2. Primary or contact point inventor(s) *Use your full first, middle and last names. Use page 2 of the expanded disclosure form for contributing inventors.*

	Name / Citizenship	SSN	Signature / Street	Dept. No. / City	Location/Rm. #	Phone Number / State, Zip
1)	Paul Gailus / US	[redacted]	Paul W. Gailus / 1301 E Algonquin Road	DQ503 / Schaumburg	IL02-2513	847-576-5961 / IL 60196
2)	Manuel Gabato / US	[redacted]	Manuel P. G / 1301 E Algonquin Road	DQ503 / Schaumburg	IL02-2513	847-576-2326 / IL 60196
3)	Kevin McCallum / US	[redacted]	Kevin J McCallum / 1301 E Algonquin Road	DQ503 / Schaumburg	IL02-2513	847-576-~~2827~~ 1077 / IL 60196

4)

3. What is the problem(s) to be solved by the invention or what is the need(s) for the invention:
There is a new market demand for communication devices supporting multiple linear modulation schemes with varying bandwidths. This requires a means for moving the pole and zero locations to change the closed-loop frequency response of a linearized transmitter. An integrated circuit solution for enabling multi-bandwidth linearized transmitters is needed.

4. What is the prior art, and why doesn't it resolve the problem(s) or fulfill the need(s):
Prior art linear feedback transmitters have a fixed bandwidth which is established by external componentry. The bandwidth could be changed by switching in additional filter components but this is costly and the size of this solution would be unacceptable for portable radio units.

5. What is the invention being disclosed?
An integrated circuit solution with variable pole and zero locations that are used to modify the closed-loop frequency response of a linearized transmitter. This invention enables a cost effective, size efficient implementation of multiple bandwidth linear modulation radio units.

6. How does this invention resolve the problem(s) and fulfill the need(s) in a new way: *Attach any drawings or diagrams you feel are necessary for clarification.*
This integrated circuit solution utilizes a single external pole capacitor and switchable integrated circuits to create an adjustable pole and amplifiers with variable gains to create an adjustable zero and loop bandwidth. This provides a solution without more external componentry than is already used and creates a linearized transmitter using Cartesian feedback that is capable of handling multiple bandwidth modulation schemes.

7. Date of conception [redacted] and if applicable, the date first built (or written) and successfully tested:

8. Product(s) this invention may be used in: This invention could be used in any system that requires multiple closed-loop bandwidths.

9. Date the first offer for sale was made for a product incorporating this invention:

10. Date the first disclosure of this invention was made outside Motorola without a nondisclosure agreement:

11. Approvals: *1)* Technical Staff or Patent Liaison *2)* Management (both required) *Signing this form attests to the fact that you understand the invention.*

	Name/Signature	Dept. No.	Location/Rm. #	Phone Number
1)	LaRonia Gordon LaRonia Gordon	DX938	IL02	85289
ok per manager's absence	Gary Grube		IL02	6-3754

12. Witnesses:
Witness: William J. Young Date: 5/24/2000 Witness: Gary Grube Date: 7/11/00

MOTOROLA CONFIDENTIAL PROPRIETARY (upon completion)

TAM V2.2 (FrameMaker version)

MOTOROLA PATENT DISCLOSURE -- Expanded Form

13. Contributing Inventor(s): *Patent Department will determine inventorship*

4) Jeff Wilhite — Signature: Jeffrey B Wilhite — Dept. No.: DQ503 — Location/Rm. #: IL02-2513 — Phone Number: 847-576-2327
Citizenship: US — SSN: [redacted] — Street: 4557 Lincoln Ave. — City: Rolling Meadows — State: IL — Zip: 60008

5) Name — Signature — Dept. No. — Location/Rm. # — Phone Number
Citizenship — SSN — Street — City — State — Zip

6) Name — Signature — Dept. No. — Location/Rm. # — Phone Number
Citizenship — SSN — Street — City — State — Zip

7) Name — Signature — Dept. No. — Location/Rm. # — Phone Number
Citizenship — SSN — Street — City — State — Zip

8) Name — Signature — Dept. No. — Location/Rm. # — Phone Number
Citizenship — SSN — Street — City — State — Zip

14. What is the business impact of having a patent on this invention, for Motorola and/or competition:

This invention could enable Motorola to be first in the marketplace with a SINGLE communications device capable of utilizing multiple bandwidth modulation schemes.

15. Expanded description; list any additional details you feel would be helpful in describing the invention:

Please see attachments.

16. Additional details concerning the prior art related to this invention:

Attach any backup documents or provide any other information you feel would be helpful in determining the desirability of obtaining a patent on this invention. Any attachments that are critical to the disclosure of the invention should be witnessed

Please see attachments.

Additional Information:

Introduction

In a communication system, it is often desirable to minimize the amount of power that is spread outside of a specified channel bandwidth to minimize interfering with a user in an adjacent channel. With digital modulation schemes becoming more and more prevalent due to their more efficient use of bandwidth, it is necessary to use linear transmitters. Motorola, Inc. developed a method of linearizing a transmitter using Cartesian feedback and used it in their iDEN products for Nextel Communications, Inc. As a result, an interest developed within Motorola to use this transmitter in several upcoming products including narrowband and wideband offerings for CGISS. Because the original linearized transmitter was designed specifically for iDEN and was not suitable for the proposed bandwidths and modulation schemes, a method of changing the closed-loop frequency response of the transmitter which minimized the need of additional external components and circuits was needed. This solution would provide Motorola with a drop-in replacement of the current linear transmitter and enable a single radio platform that is capable of utilizing multiple bandwidths and modulation schemes.

The current linear transmitter has 2 fixed poles and 1 fixed zero and is designed for a linear modulation scheme that occupies a 25kHz bandwidth. This invention proposes modifying the current linear transmitter with circuitry that provides 1 fixed pole, an adjustable gain, 1 adjustable pole and 1 adjustable zero.

Prior Art: Fixed Poles and Zeroes

The current implementation of cartesian feedback in the iDEN system utilizes a loop response consisting of two poles and one zero. The system utilizes one dominant pole in the integrator following the summing junction which sets the desired loop gain at a single operating frequency. In order to reduce the closed loop transmitted noise beyond this operating frequency, a second pole is placed at the desired loop bandwidth. This pole adds additional attenuation of noise beyond the loop bandwidth. The second pole also adds additional phase shift in the loop which could cause loop instability. This excess phase shift is countered by the addition of a zero in the loop response (see section on Adjustable Zero). The actual implementation of the poles in the cartesian is loop is done by external capacitors connected to pins on the linearizing IC (TRANLIN, ODCT, LNODCT). The large values of these capacitors make them unsuitable for integration. In order to allow multiple operating bandwidths using the linearizing IC's available today, the values of these external capacitors would need to be externally modified via switching. This would result in the need to provide external switching circuits and additional capacitors. Implementation of an adjustable pole / zero circuit which can be integrated and that does not add any additional pins or components to the linearizing IC is required.

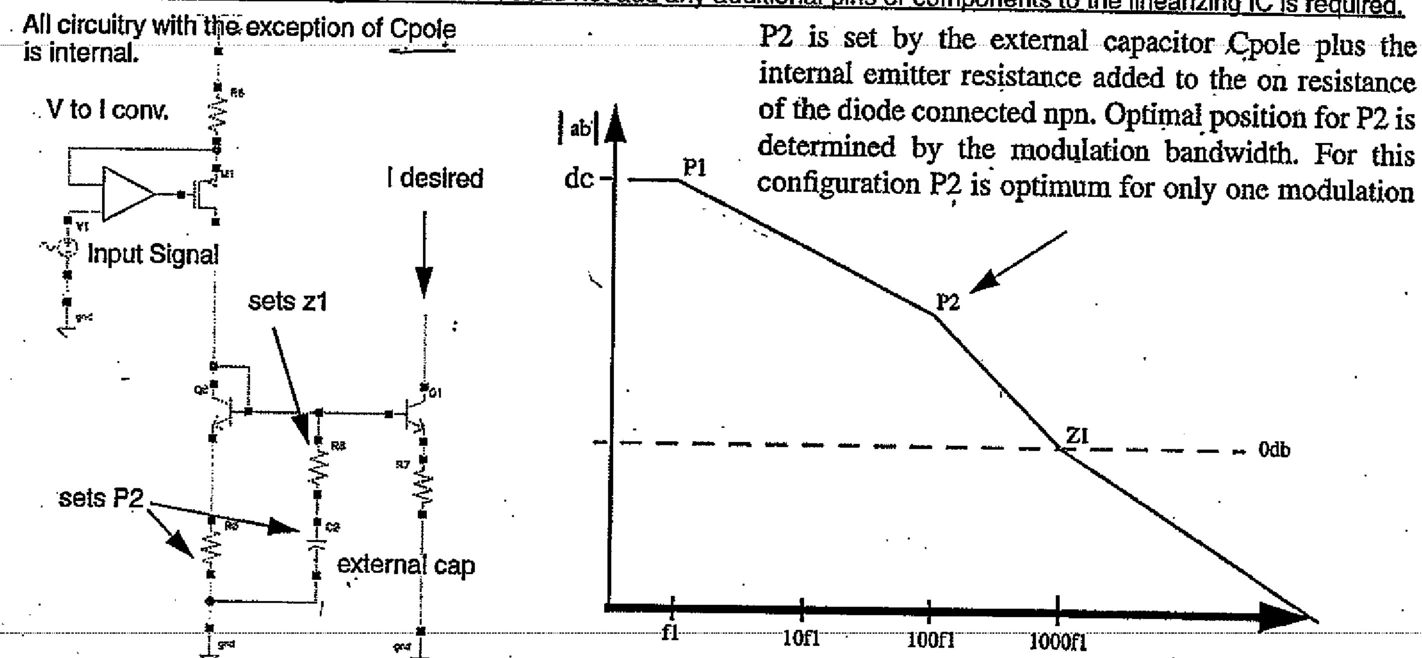


Figure 1 Prior Art

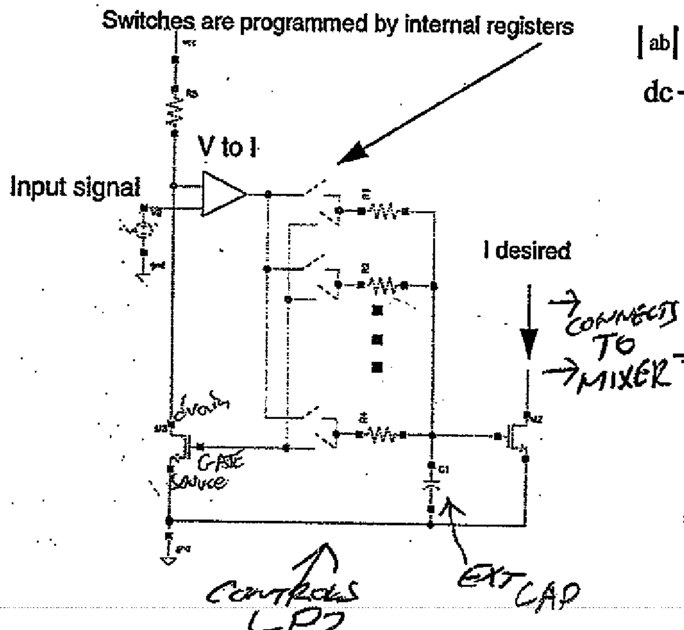
Consider the circuit shown in Figure 1. This figure shows the pole / zero implementation as it exists today in the linearizing IC. Capacitor Cpole is set for the desired loop bandwidth and the series resistor sets the zero position required for stability. It's effect

Additional Information:

on the loop response is also shown in figure1. It is obvious from the loop response that the value of Cpole is only optimal at one loop bandwidth. Also, the pole setting resistor value is highly constrained by its effect on DC operating point and signal gain. Therefore, moving the pole frequency requires changing the external capacitor value. The physical placement of the zero at the end of the circuit lineup limits the rolloff of noise by the pole from previous circuitry.

New Invention: Adjustable Loop Bandwidth

Figure2 shows a circuit which allows for Cpole to be optimum at several loop bandwidths using the same external capacitor. The desired bandwidth is selected by internal programming of the linearizing IC which selects from a group of internal resistors which combined with a single external Cpole sets the desired position of P2. The circuit uses active feedback with FET based current mirrors to allow selection of a wide range of resistor values while maintaining a high degree of linearity and low noise. Also, the pole setting resistor choice has no effect on the DC operating point or gain. The zero is moved to an earlier stage in the lineup to allow the pole to provide full attenuation of the wideband noise contributed up to this point.



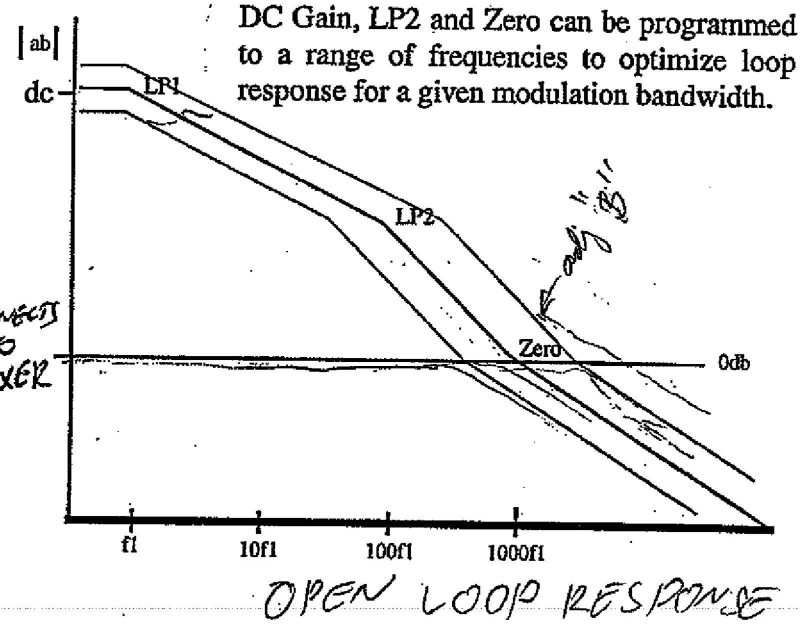
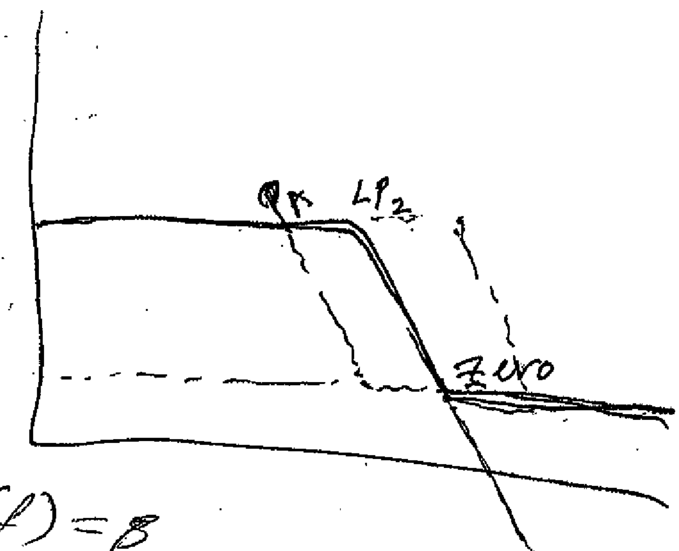
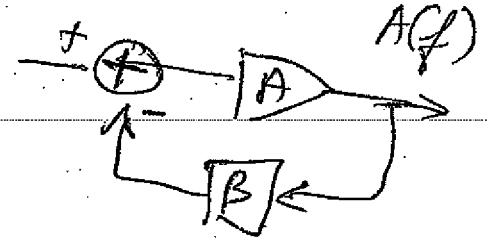


Figure 2

Adjustable Zero



$$G_{CL} = \frac{A}{1 + A\beta}$$



$\beta(f) = \beta$

Additional Information:

In circuit theory, a first order low-pass filter provides -20dB/decade roll-off in the frequency response as shown by Figure 3.

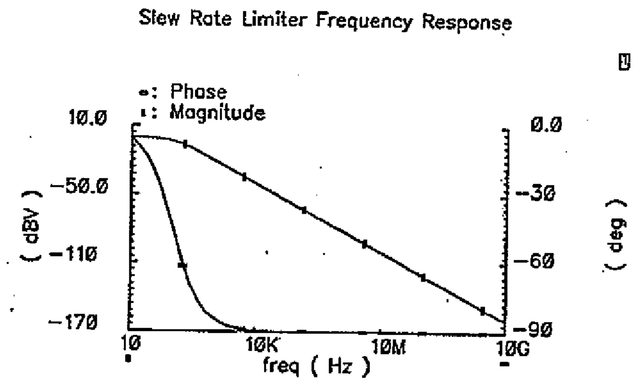


Figure 3. Single Pole Frequency Response

The purpose of adding a zero is to provide a +20dB/decade rise in the frequency response to cancel the -20dB/decade response of the pole and add positive phase compensation to help stabilize a closed-loop feedback system. In theory, an active circuit can be used after a low-pass filter to create the desired magnitude and phase response of a zero. This is done by summing the original signal with a low-pass filtered version of the original signal. If the output of the active circuit is low enough, the single pole response dominates the output at low frequencies. As the frequency increases beyond the low-pass corner frequency, the single pole's dominance begins to decrease and the active circuit's dominance begins to increase. At increasingly higher frequencies, the active circuit dominates the output. Because of the constant gain of the active circuit, the frequency response of the system resembles that of a pole-zero network.

To prove the theory of the active zero circuit, a model using ideal, variable gain voltage sources was created. Figure 4 shows the idealized model of the active zero circuit. The upper signal path is the first order low-pass filtered path. This provides the -20dB/decade frequency response. The corner frequency was set around 100 Hz. The lower signal path is the active zero circuit. Notice that the lower signal path just passes the input signal of the low-pass filtered path. The outputs of those 2 paths are summed together. If zero compensation is desired, then the lower path is enabled. If the lower signal path is disabled, the origi-

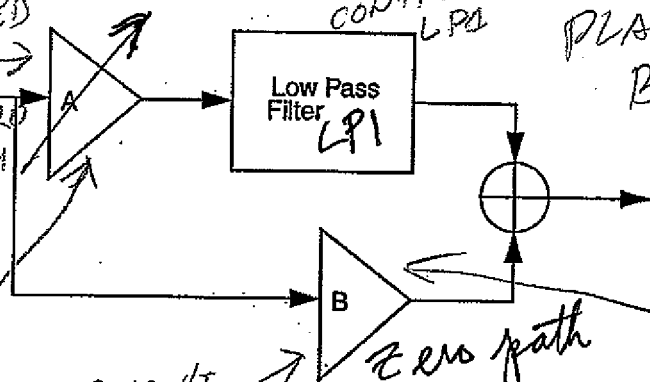
Additional Information:

nal first order low-pass frequency response is preserved.

ADJUSTED FOR /ZERO ALONG WITH FIG2 CIRCUIT

CONTROLS LP1

PLACED BEFORE CIRCUIT 2 PAGES EARLIER (FIG2)



IS 32dB IN JAVELIN, CAN BE CHANGED

B ISN'T CHANGED UNLESS 0dB GAIN POINT TO BE ADJUSTED

THIS IS DC GAIN OF OL RESPONSE. SWITCHED IN 6dB STEPS

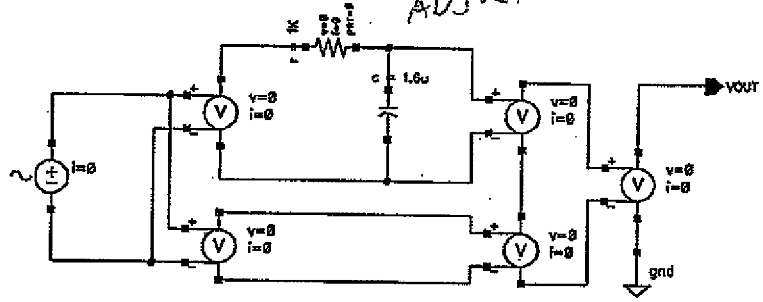


Figure 4 Idealized Model of the Active Zero Circuit

Figure 5 shows the single pole frequency response with the active zero circuit enabled. Zero compensation can be observed by the addition of +45 degrees to the phase response and the cancellation of the -20/decade rolloff at approximately 10 MHz in the magnitude response. Thus, the active zero circuit does what the theory describes and provides zero compensation to the overall frequency response.

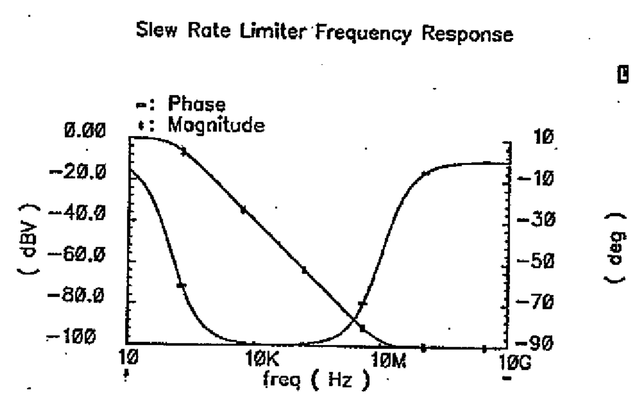


Figure 5 Active Zero Compensation

Additional Information:

If the gain of the active zero circuit is increased, the frequency at which it dominates the output decreases. If the gain of the active zero circuit is decreased, the frequency at which it dominates the output increases. Thus, the theory behind adjustable zero compensation is that we can change the zero location by adjusting the gain of the active zero circuit.

Figure 6 is a schematic of a semi-ideal model of the slew rate limiter in the Offset Direct Conversion Transmitter (ODCT) IC which is the original linearized transmitter IC with the active zero circuitry. The slew rate limiter was chosen because it is the circuit that will be modified to accommodate the active zero circuit. A differential amplifier receives the differential input signals. The output of the differential amplifier is buffered and then filtered. One pair of buffer amplifiers is used to simulate the slew rate limiter's single-pole response and the second pair of buffer amplifiers is used to simulate the active zero circuit. The 2 signals are summed using the collector currents of 2 differential amplifiers. The gains of the amplifiers that are used to sum the 2 signals are determined by setting the tail currents of each of the differential amplifiers.

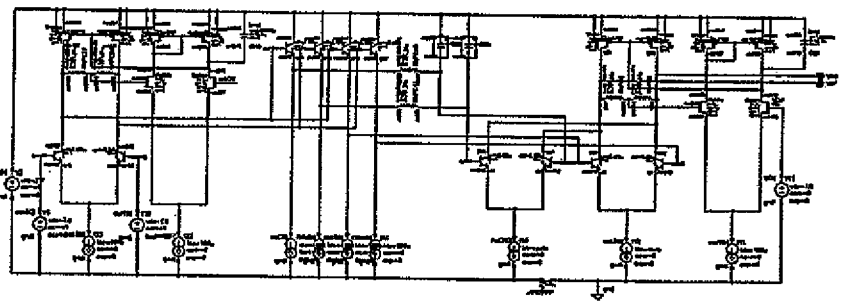


Figure 6 Semi-Ideal Model of the Slew Rate Limiter

Figure 7 shows the frequency response of the semi-ideal slew rate limiter with the active zero circuit disabled. As expected, the frequency response is the first order low-pass frequency response of the slew rate limiter.

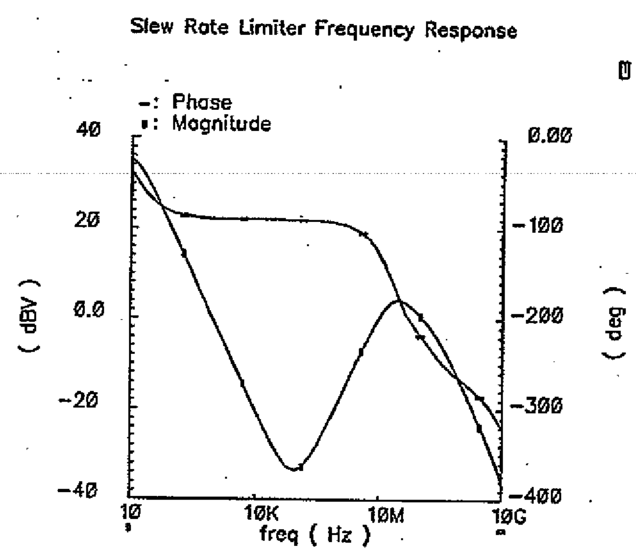


Figure 7 Uncompensated Slew Rate Limiter

Figure 8 shows the slew rate limiter's frequency response with active zero circuit enable. Note the addition of +45 degrees of phase compensation and the flattening of the magnitude response curve between 10 kHz & 100 kHz which are characteristics of

Additional information:

zero compensation.

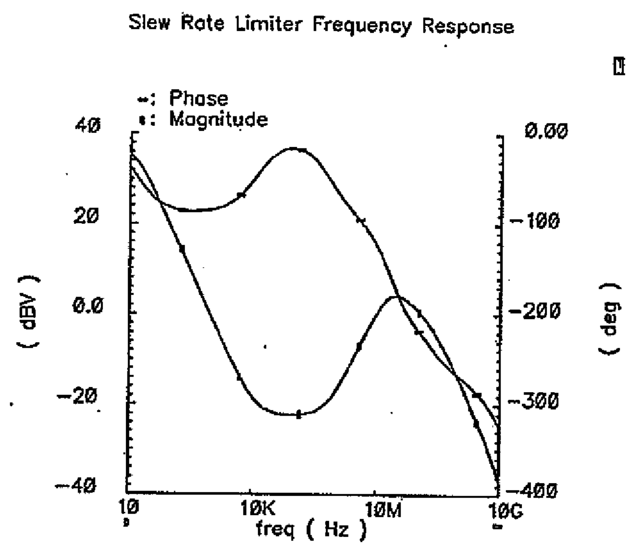


Figure 8 Compensated Slew Rate Limiter

Figure 9 shows that maintaining the same tail current ratios but increasing the individual tail currents of the summing amplifiers can change the frequency response of the slew rate limiter.

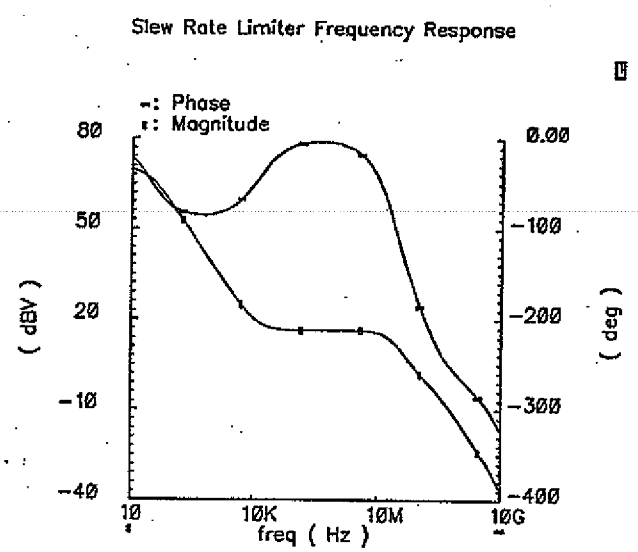


Figure 9 Compensated Slew Rate Limiter

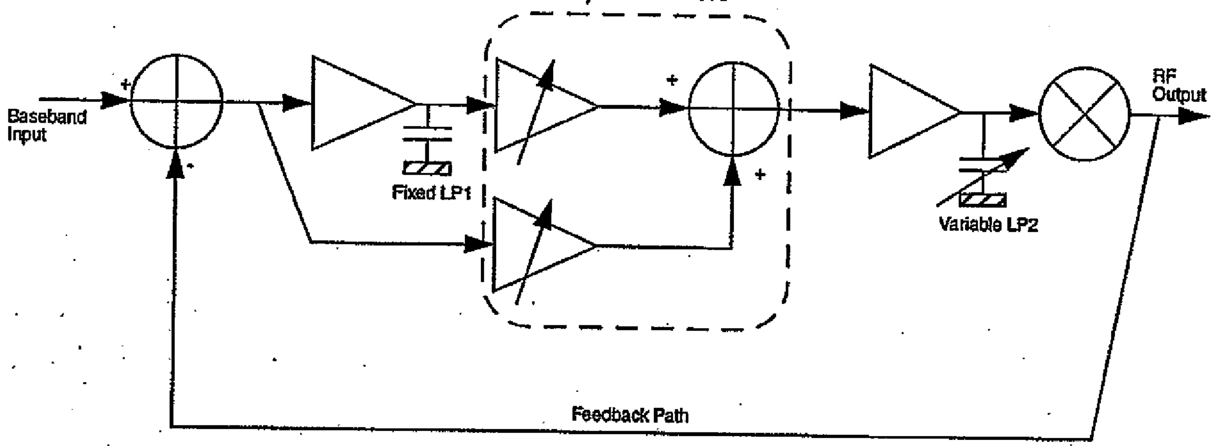
These simulation results prove that active zero compensation with real devices is possible.

Closed-Loop Frequency Compensation

The adjustable pole when used in conjunction with the active zero circuit creates a single, drop-in solution to the current ODCT IC that enables a single radio platform which is capable of utilizing multiple bandwidth linear modulation schemes with a mini-

Additional Information:

·mum of additional external components.



Multi Bandwidth Closed-Loop Block Diagram